IV. STRESSES TO CORAL REEFS

OVERVIEW

The charts below summarize the suggested components of a basic monitoring program that will address a variety of situations. In all cases, it is a good idea to use photography to document your study sites.

For this situation:	For a basic monitoring program, you should:
Coral bleaching	Monitor individual coral colonies; measure water temperature, PAR, and UV.
Damage by boats, snorkelers, divers	Measure physically damaged area; record number of broken coral branches.
Over-fishing	Census reef fishes.
Sediments from dredging or runoff	Measure sedimentation rates and bacterial concentrations.
Orinoco plume	Measure water temperature, water transparency, salinity, and chlorophyll concentration.

In these situations, you should be monitoring at established quadrats or transects in the affected areas and at control sites.

Baseline monitoring	Monitor individual coral colonies and live coral cover; measure water temperature, algal biomass, water transparency, and salinity; census reef fishes.
Sewage or other nutrient influx	Monitor individual coral colonies; measure nutrients, water temperature, algal biomass, live coral cover, salinity, dissolved oxygen and bacterial concentrations.
Desalination plant effluent	Measure water temperature and salinity.
Storm damage	Monitor individual coral colonies; measure algal biomass; census reef fishes.
Oil spill	Monitor individual coral colonies.

A detailed, comprehensive discussion of the effects of all these stresses on reefs is outside the scope of this manual. Some of the human activities that cause physical damage to the reef structure are described below with suggestions for monitoring.

SCUBA DIVING AND SNORKELING

The growing number of snorkelers and divers is resulting in increasing damage to coral reefs. The harm caused by SCUBA diving depends on the skill and training of the divers and dive operators. Especially at heavily used sites, divers may stir up sediments and break corals. However, unless you actually see the damage taking place, it's difficult to know for certain its cause.

In very shallow areas where fragile branching corals are abundant, damage from snorkelers can present a management problem. For example, a park manager may need information to determine whether an underwater trail should be closed and snorkelers moved to another location to allow the initial site to recover. Ideally, underwater trails should be placed in areas deep enough to reduce damage from fins, but the best protection comes from educating snorkelers and divers.

To quantify damage to elkhorn coral (*Acropora palmata), you* need to consider both the number and size of the breaks. Here's an easy way to do this:

Estimating Damage to Elkhorn Coral

1) While swimming parallel transects across the reef area, count the number of freshly broken branches of elkhorn coral.

2) Measure the "length" and "width" of each fracture area or stump with a small plastic ruler marked in millimeters. Because most fracture areas in elkhorn corals are elliptical, the length and width measurements can be used to calculate areas using the formula for an ellipse.

$$\text{Fracture Area} = \text{Length} \times \text{Width} \times 0.8$$

3) Although you don't have to swim exactly the same transects each time, it's helpful to know the total area being surveyed so that you can estimate the density of coral breaks, i.e., the number of breaks per square meter.

Monthly observations of snorkel sites are most effective. If surveys are made more often, distinguishing new breaks from old ones is often difficult, so the same break may be counted more than once. If surveys are made less often, breaks occurring since the last survey will be difficult to see, as algae grow rapidly over freshly broken areas (sometimes within a week).

Reference

Rogers, C.S. McLain, L., Zullo, E. (1988) "Damage to coral reefs in Virgin Islands National Park and Biosphere Reserve from recreational activities," Proceedings of the 6th International Reef Symposium 2:405-410.

BOAT GROUNDINGS AND ANCHORS

Dramatic increases in boating in Florida and the Caribbean have led to an increase in boat groundings and anchor damage. This section contains some suggestions on how to conduct a general survey of damage from small boats and large cruise ships, and how to assess the damage resulting from a particular anchoring or grounding incident. Aerial photographs of popular bays and anchorages can be used to estimate the increase in number of boats using an area over time.

Depending on the depth, you'll need to use snorkeling or SCUBA to record the necessary data. It is important that only experienced divers investigate near anchors and anchor chains, especially those of large ships. If the anchor is being raised, you should not be anywhere near the ship! If the damage occurred in a protected area and legal action may be taken, do not attempt any rehabilitation until you've consulted with the appropriate legal authorities.

General Survey of Anchor Damage

If you are concerned about the effects of anchoring in a particular bay or at a dive site, you can dive on the anchors from several boats and:

1) Record the time of survey, boat length, type of boat, type of anchor, length of anchor chain resting on bottom, depth, and bottom type (coral, seagrass, sand, rubble, pavement, and mud).

2) Rate the observed damage on a scale of 1 to 5, from negligible to severe.

3) Analyze your data to describe the magnitude of the damage from anchoring, and restrict anchoring if appropriate.

Specific Incidents

When you wish to assess the damage caused by a specific boat grounding or anchoring incident, your approach will depend partly on the size of the affected area. But in all cases it is essential to record the site location by marking it on a map or listing the compass bearings to fixed locations; determine the GPS or LORAN coordinates. Landmarks, compass bearings, and buoys are often needed to help find the site again. For more suggestions, see "Marking the Site," I-16.

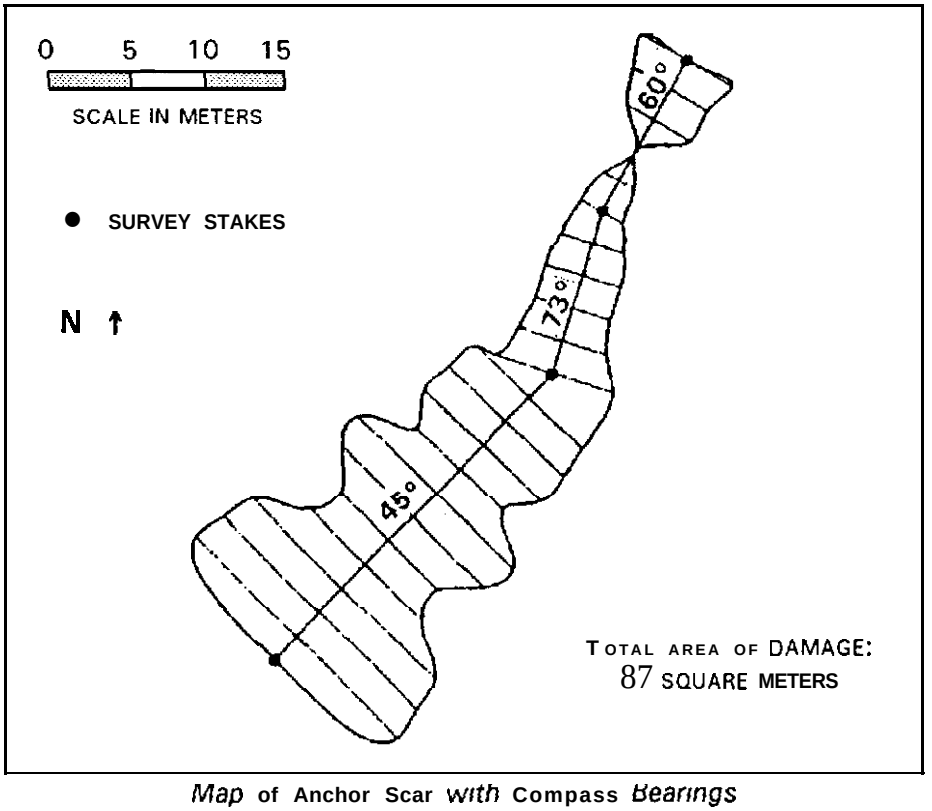
For a small grounding site or anchor scar: If feasible, mark the perimeter of the damage and/or the location of the grounded boat by installing re-bar stakes or other permanent markers which will facilitate future monitoring. Then record distances and compass bearings from stake to stake, and estimate the size of the damaged area by measuring it, or plotting stake locations and digitizing the resulting map. Because underwater compasses do not give accurate compass readings, it is important to use surface buoys attached to the bottom and a "boxed" (calibrated) compass on the boat to determine the exact location of the scar.

For a larger grounding site or longer anchor scar: Extend a tape measure across the approximate center axis of the scar, which may have several turns.

1) Secure the tape to stakes or coral rubble at both ends and at intermediate points as needed so this base line will remain in place during measurements.

2) Record the compass bearings of the scar. If the scar is not straight, record the bear ing of each segment. These data will be important for locating the site again and for constructing computerized maps of the scar.

3) To measure the overall size of the scar; measure the perpendicular distance from the base line to the edge of the scar at 2-3 m intervals. The edge of the scar will usually be quite conspicuous because of the presence of injured corals and/or loose debris.



Map of Anchor Scar *with* Compass *Bearings*

For very large **areas:** An alternate method, especially appropriate for very large areas, is to construct a grid of 10-m squares (or other appropriate size) over the scar. Estimate the percent of damage within each square, as described in the next section. While it is important to be as quantitative as possible, constraints on divers' bottom time may require compromises on accuracy and detail if the area is in deep water or is very large.

Aerial photography: If the damage is several hectares in size, it may be best to use aerial photogrammetry. To provide a reference scale in the image, you can use blue plastic tarpaulins, 12 ft by 12 ft on the sea floor adjacent to the damage.

Estimating Coral Damage

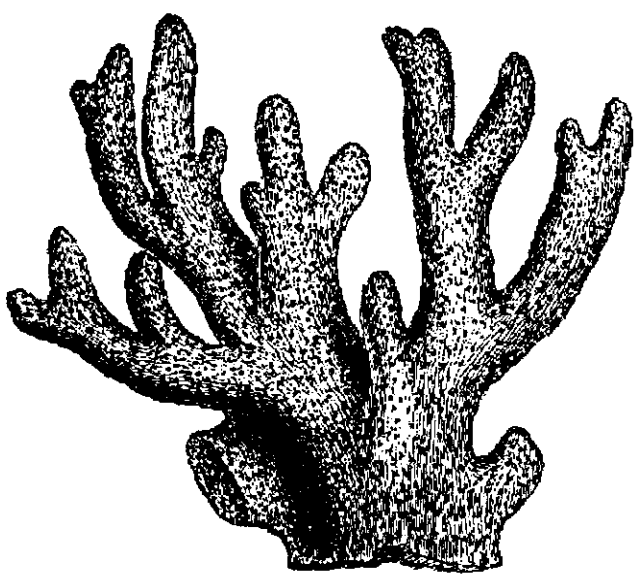
To estimate the percent of live corals and other organisms as well as the amount of damage, use 1 m^2 quadrats made of PVC pipe and divided into 100 squares with nylon line. Each square therefore represents 1% of the quadrat.

1) Place the quadrats randomly along the measuring tape or transect lines, and randomly on nearby undamaged reef so that you can estimate what the coral community in the affected area was like before the damage occurred.

2) Record not only the amount of damage, but the type (e.g., abrasion, scour, pulverization, fragmentation). If a 10-m grid is used, two observers should estimate the amount of remaining live cover and average their two values.

3) If possible, count the number of overturned or fragmented coral heads and pieces of substrate in the entire area. Otherwise, count the numbers in a known area (e.g., 20 m^2) and extrapolate to the entire affected area. Depending on the size of the area and your available resources, you may need to set an arbitrary size limit on the coral heads and rubble that you include in your count.

You can also estimate the percent live cover in the damaged and nearby undamaged areas on the reef by using a linear chain transect or line intercept transect method. Depending on your objective, you may decide to measure only live coral colonies or all reef components.



SUMMARY

The monitoring techniques described in this manual are presented as a guide to some of the methods that have proved useful in coral reef monitoring programs in the Caribbean and western Atlantic region. This manual does not include all monitoring techniques currently in use, but it provides details on numerous methods used to examine and document information on the physical, chemical and biological parameters of the coral reef ecosystem. Other manuals on coral reef monitoring that you may find helpful are listed under "Information Sources." VI-l.

These tools will enable you to collect the baseline data necessary to document changes in the ecological and structural components of the reef. You can then use that information to evaluate and assess impacts, both natural and human, to the coral reef ecosystem. Baseline information is a prerequisite to understanding the natural system, and a better understanding of the current status of the reefs is essential before management decisions can be made.

A comprehensive monitoring program should encompass physical, chemical and biological components. Information collected about the physical condition of the reef will help to explain biological characteristics noted at the study site. Most of us are operating under many constraints with limited personnel, equipment and funding, but it is crucial that we begin collecting baseline information. No matter how small your budget, there are monitoring techniques outlined in this manual that can provide valuable information. Do not underestimate the usefulness of collecting even the most basic data; qualitative documentation is better than nothing. Although you will need to tailor a program which is suited to your specific objectives, budget and time frame, use of standardized methods outlined in this manual will facilitate discussion and comparison of data throughout the region.

Good luck!